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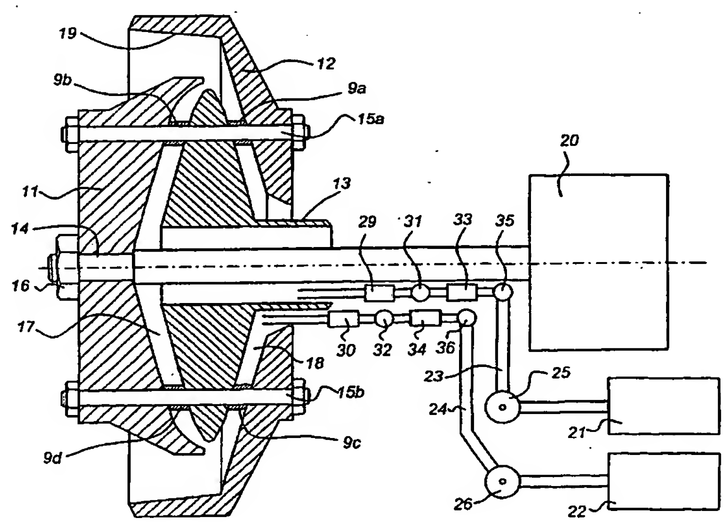
(54) Title: PROCESS, SYSTEM AND EQUIPMENT FOR THE APPLICATION OF COATINGS ONTO WALLS OF TUNNELS, PIPES, TUBES AND THE LIKE



(57) Abstract: Spray head for spraying a coating onto the inner wall of a tunnel, pipe, tube or other elongated space of relatively limited diameter, which spray head has a central shaft (14) that runs in longitudinal direction during operation and can be rotated by a driving motor. For each component, the spray head has a mainly diametrically running disc-shaped acceleration room, whose diametrically smallest shaft-oriented inner side is connected, through a known coupling, to a component supply channel, and whose diametrically largest outer side is open, at least partially, forming a discharge gap through which the relevant component is flung out in approximate diametric direction during operation.

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Process, system and equipment for the application of coatings onto walls of tunnels, pipes, tubes and the like.

The invention is related to a process for the treatment of walls of tunnels, pipes, tubes or other elongated spaces, involving the coating of the wall after a possible pre-treatment. The invention also concerns a system that enables this process to be used as well as specific equipment that can be used within this system.

State of the art

Processes for the treatment of walls of tubes, pipes, tunnels or other mainly horizontally running passageways are known from the state of the art. In this specification the term 'mainly horizontally' also relates to sewer pipes and the like which, in order to function properly, are laid to falls and, therefore, do not actually run exactly horizontally.

These known processes are, for instance, used:-

- to clean the relevant wall with cleaning agents;
- to impregnate the wall with impregnating agents;
- to apply a concrete mortar lining;
- to coat the wall with synthetic or other suitable materials.

Some processes, and the equipment used for these processes, have turned out to be successful, whereas others never got beyond the experimental stages.

If use is made of materials whose consistency does not actually change during the process, such as water whether or not containing solved or mixed cleaning agents or other additives, few problems will generally occur in supplying them and spraying them onto the wall.

If, however, use is made of materials whose consistency does change during the process, such as paint, curing synthetics, concrete and the like, problems are often encountered, especially due to obstructed lines, spray nozzle and the like. Other problems may arise with regard to the thickness of the coat sprayed onto the wall and to the filling of seams, cracks or other openings in the wall.

To apply a coat of material of certain thickness onto the inner wall of a tunnel, tube, pipe or the like, it would be advantageous to be able to use materials that are

made up of two or more components, which components are separately transported to a spray nozzle, and sprayed through this nozzle onto the wall, during which spraying process the components are mixed. The moment the components are being mixed, the mixed material starts to cure. The moment the material hits the wall, it will adhere to it, and form a layer that will not or hardly flow any more as a result of the curing that will have started by then. For this reason, the use of quick-curing materials is preferable.

Currently, synthetic materials are available which are made up of two or more components, and cure so quickly that, after the components have been brought together, only very little time, in the order of seconds, is left before the curing has reached a stage where the material has changed from 'liquid' to 'solid'. In theory, the benefit of such materials is therefore that relatively thick coats can be applied in one go. It is also possible to apply multiple coats at short intervals if an even thicker coat is to be created.

On the other hand, the equipment used must be able to process such materials. The equipment known so far has however not always turned out to be successful, especially in the processing, in normal production environments, of quick-curing synthetic materials consisting of two or more components. A number of prior art apparatuses will be discussed.

A first prior art apparatus is described in US3233580. This specification describes a spray head comprising an internal space in which two components are received and become mixed. The mixture is guided into a second internal space having a slanted wall along which the mixture is guided to an edge from which the mixture is hurled in approximately diametrical direction to the wall to be coated. Because the mixing is done in an internal chamber this spray head is definitely not suited for spraying fast reacting components.

A second prior art apparatus is described in US5018954. The spray head described therein comprises one approximately disk shaped chamber made of two cone-shaped parts directed towards each other and defining an open slit at their diametrically largest boundary. The embodiment illustrated in figure 6 is destined for handling two different components of a coating. Each component is delivered onto the inner wall of one of the cone shaped parts. During operation both cone shaped parts will rotate along the same central axis and under the rotational forces each component will move in the diametrically outside direction towards said split where both compo-

nents will become mixed and from where the mixture is hurled away. No measures are taken to prevent drops of the one component being splashed onto the other wall of the chamber, which would result into unwanted curing of material. Furthermore the mixing operation will take place in the split edge of the chamber. In case fast reacting components are used it almost certain that within a rather short time the chamber will become blocked by a hardened mixture of components which found each other inside the chamber and did react so fast that they are already hardening and become attached to the chamber wall before they have the change of leaving the chamber. Finally both cone shaped parts are counter-rotating so that in fact the components are not hurled away with relatively high speed, but are injected in low velocity air whereby very short droplet trajectories are realized. So this prior art apparatus is certainly not suited for spraying a two component coating onto the wall of a tunnel, pipe, etc.

A third prior art apparatus is described in US 478595. This prior art spray head comprises one chamber in which all the components introduced and from where the mixture is moved to the edge of a cone-shaped part to be sprayed around. Because of the mixing inside a thereto-destined chamber this apparatus is not suited for handling fast curing two or more component materials. Further proof therefor is found in the fact that a separate conduit is installed for supplying a washing agent to the mixing chamber for cleaning said chamber. For two components fast curing materials that is not a workable proposition.

In general problems occur with the prior art apparatuses in particular when the process is being started up, the equipment is being set up, and the process is being ended. To obtain proper coating material, the components will have to be processed in a correct ratio and at the correct temperature and pressure. Given the short curing time, it has to be ensured during the set up of the equipment that the components always keep on flowing within the spray head, otherwise the mixing chamber will get obstructed with curing material, which in many cases leads to the relevant head having to be discarded. When the process is being ended, it must likewise be avoided that mixed components are left behind in the mixing chamber or in the spray nozzle, otherwise this may lead to an obstruction that will be difficult, if not impossible, to remedy.

Objects of the invention

The objects of the invention are to indicate what requirements are to be met by equipment for the treatment of tunnel walls and the like, and how such equipment is to be designed to provide inner walls of tunnels, tubes, pipes and the like with a coating made of a quick-curing, two-or-more-component synthetic without the problems identified above occurring.

The invention

These objects are fulfilled by a spray head for spraying a coating onto the inner wall of a tunnel, pipe, tube or other elongated space of relatively limited diameter, which spray head has a central shaft that runs in longitudinal direction during operation and can be rotated by a driving motor. The spray head is according to the invention characterised in that, for each component, the nozzle has a mainly diametrically extending acceleration room, whose diametrically smallest shaft-oriented inner side is connected, through a known coupling, to a component supply channel, and whose diametrically largest outer side is open, at least partially, forming a discharge gap through which the relevant component is flung out in approximate diametric direction during operation.

So, the different components are flung out from approximately parallel, adjoining gaps in the direction of the wall to be coated. During the passage to the wall as well as on the wall itself, the components are mixed, and the curing process will start. This curing happens so quickly that no or hardly any 'sags' occur, and a smooth hard coating is obtained.

The driving motor can be e.g. a hydraulic motor, an air motor or an electric motor (or any other suitable motor co-operating e.g. with a gear box to achieve a high rate of revolution.

In each acceleration room the respective component will be guided and accelerated along the walls of said room. To promote the motion of the component along a wall it is preferred that the respective wall extends not perpendicular to the central shaft but with an angle somewhat smaller then 90 degrees thereto. Therewith the component is subdued to a small force directed to the wall so that the component is more or less pressed against said wall.

And will move as a thin film along said wall in diametrically outside direction.

In many designs it is preferred that the component will move along one specific wall of the acceleration room. Than at least that wall has to be non-perpendicular to the driving shaft. It is thereby further preferred that the design of the shaft orientated inner side of each room is such that the component entering the room will be guided mainly to said non perpendicular wall.

Improved mixing may be realised in a preferred embodiment of the spray head which according to the invention is characterised in that the spray head has a flat, plate-ring-shaped target plate, which is located on the fling-out route of each of the components, and whose inner side makes an angle to the axial direction such that the components end up on this target plate, and are moved to the edge of the target plate by the centrifugal force, whereby the components are mixed and flung out over the edge of the target plate in radial direction.

The components are not mixed until they have left the spraying room. The risk of obstructions occurring in the spraying rooms due to materials curing is therefore very small. Mixing is stimulated by the present target plate. As long as the material on the target plate is in motion, there is little risk of obstruction or adhesion of curing material. Yet, to minimise this risk, it is preferred that at least the inner side of the target plate is made of a material that has poor adhesive characteristics, or is lined with such material. Good examples of suitable materials are polyethylene, quartz oxide, aluminium oxide, nylon, polyurea, teflon and PEEK, of which the latter three materials are preferred. Further preferred is the use of carbon reinforced PEEK as construction material for manufacturing the whole spray head.

To minimise the risk of undesired adhesion of material even more, it is preferred that the component with the highest liquidity is guided through the head such that it will move across the target plate longer, and that the component with the lowest liquidity is guided through the spray head such that it will move across the target plate shorter. This ensures that the longest route across the target plate is taken by components which, by nature, flow across the plate more easily, while materials with lower liquidity will follow a shorter or the shortest route across the plate.

The above assumes that the various components are in reservoirs located outside the tunnel. Through hoses or other channels, the components are supplied from the reservoirs to the spray head. Known systems often use control valves for regulating the

flow of each of the components, with these valves located near the reservoirs. This may function properly if use is made of components that cure only slowly when being mixed. A component flow in the spray head can be stopped and started only with some delay, and often gradually rather than instantly, as there will have to be some pressure increase or decrease in the long lines between the reservoirs and the spray head. For quick-curing materials, the response time of such control valve is therefore much too long for proper control due to the hose between spray head and valve.

It is therefore preferred to use a spray head control system, which according to the invention is characterised in that, for each supply line, the spray head is equipped with a flow meter and a control valve, with each flow meter transmitting a signal to a processor that compares the signal with a set value, which comparison produces a control signal for the control of the relevant flow control valve. The place of measurement is now in the immediate vicinity of the place of control, so that any influence of in-between hoses, tubes and the like is eliminated.

Furthermore, it is preferred that, for each component, a temperature meter is coupled to the relevant supply conduit, and that all temperature meters transmit signals to the processor which, based on those signals, corrects the control signals to the control valves. With that, it is assumed that the viscosity of the various components depends on the temperature, and that the temperature must therefore be involved in flow control.

It is also preferred that the supply conduits have heating means that ensure that each of the components in the supply conduits has a preset temperature on entering the relevant spraying room. Given the relatively high flow rate of the components in the spray head itself, heating means in the spray head itself will be effective only to a very limited extent.

With that, it is preferred that the heating means can be controlled by the processor based on the temperature signals received.

It is also preferable that there is a pressure control valve for each component; that, for each component, there is a pressure gauge that transmits pressure signals to the processor; and that the processor controls the pressure control valves based on the pressure signals received.

As both the pressure control valve and the earlier-mentioned flow control valve actually enlarge or reduce the flow through orifice, the functions may be combined in

one single valve.

With reference to the control features it is remarked that control circuits are already known from the prior art. A number of examples will be discussed shortly.

US4294612 describes a system for applying foam insulation. The foam is manufactured by bringing together a resin and a foaming agent within the mixing chamber of a spraying gun. The resin is stored in a first reservoir while the foaming agent is stored in a second reservoir. The materials are drawn from their reservoirs by means of a pump set, which moves the materials under pressure via flexible hoses into the spraying gun. In practice the hoses are relatively long. (see column 2, lines 51-63). As clearly illustrated in figure 1 the sensors and valves of the control system are installed (in material flow direction) behind the reservoirs but before the relatively long flexible hoses. That implies that these sensors and valves are certainly not installed within the spraying head or directly preceding the spraying head.

EP0326510 describes a system for transporting two components from respective reservoirs to a spraying head in which the components become mixed. Coupled pumps are used to drive the components from the reservoirs through flexible hoses into the spraying head. The only control means illustrated in figure 2 is a temperature sensor 103, which is mounted on or in said hoses (see column 5, lines 14-15). It is clear that this sensor is certainly not installed within the spraying head or directly preceding the spraying head.

JP2000153184 describes an apparatus for applying a multi-color coating. Controllers 9 are used to regulate the flow of each of the coating components. As will be clear from the figures and from the English abstract "the controllers are set in the respective supply paths" and therefor not within the spraying head or directly preceding the spraying head.

US2001/0000611 describes a two channel system whereby pressure sensors 58, 60 and flow meters 66, 68 are build into the flow channels and certainly not within the spraying head or directly preceding the spraying head.

A completely different control circuit is illustrated in US4738219. The only sensor is a temperature sensor 14 installed inside the coating booth 13 in which the articles to be coated are positioned. The sensor is therefor not installed within the spraying head 19.

As noted earlier, the spray head is not an independently functioning unit but is

part of a system.

The invention therefore provides for a system that includes:-

- reservoirs for storing the coating components;
- a spray head for applying the coating onto the tunnel wall;
- conduits between the reservoirs and the spray head for supplying the coating from the reservoirs to the spray head;
- means for moving the spray head through the tunnel,

with the spray head embodied as described above.

Furthermore, the invention provides for a system that includes:-

- reservoirs for storing the coating components;
- a spray head for applying the coating onto the tunnel wall;
- conduits between the reservoirs and the spray head for supplying the coating from the reservoirs to the spray head;
- means for moving the spray head through the tunnel,

with the spray head being controlled by a control system as described above.

The spray head and the control system, as invented, can be applied within several processes.

A first example of such processes can be described as follows: process for the repair and improvement of walls of tunnels, pipes, tubes or other elongated spaces of relatively limited diameter, featuring the following steps:-

a1 cleaning of the wall by spraying a suitable cleaning agent against the wall using a suitable nozzle;

a2 removal of loosened dirt and cleaning agent by spraying water against the wall using a suitable spray gun;

a3 application of a layer of textile or woven metal or similar material onto, as a minimum, those spots where the wall is damaged (cracks, loose bricks, fallen-out sections and the like);

a4 next, application of a suitable coating onto the wall using a suitable spray head.

Preferably, any water and dirt accumulating on the tunnel bottom will be sucked away during and after step a2.

Furthermore, it would be preferable to insert a break between the steps a2 and a3 to allow the wall to dry sufficiently. Of course, other actions may be taken to dry the tunnel wall.

Another example of a process can be described as: process for the repair and improvement of walls of tunnels, pipes, tubes or other elongated spaces of relatively limited diameter, featuring the following steps:-

b1 application of a layer of textile, metal or similar material onto, as a minimum, those spots where the wall is damaged (cracks, loose bricks, fallen-out sections and the like);

b2 next, application of a suitable coating onto the wall using a suitable spray head.

For both processes, it holds good that, preferably, the step a3 or b1 is carried out by a suitable robot;

Concise indication of the figures

Below, the invention will be explained in more detail with reference to the attached figures.

Figure 1 shows a cross-section of the spray head according to the invention.

Figure 2 shows a diagram of a control system to be used with the spay head according to the invention.

Figure 3 shows an other embodiment of a spray head according to the invention.

Description of figures

Figure 1 shows a spray head that may be used within the scope of the invention. The spray head is made up of the three form parts 11, 12 and 13, which are fixed onto each other and onto the shaft 14 using suitable fasteners. In the figure, a number of bolts 15a, 15b,... are used to fix the form parts 11, 12 and 13 onto each other whereby washers or distance bushes 9a, 9b, 9c, 9d,..... are used to mutually position the form parts 11, 12 and 13. It will be clear that there are many other options to bring this about. The form part 11 is moved, in the way shown, onto the thinner end of the shaft 14 and, next, fastened with the nut 16. The form of the parts 11, 12 and 13 has been chosen such that the parts form, in between them, the two disc-shaped spaces 17 and 18, which will be referred to below as the 'acceleration spaces'. The diametrically outer end of the part 12 forms the target wall 19, the goal of which will be discussed later on. The shaft 14 is coupled to the driving motor for the rotation of the shaft.

The components from which the material to be sprayed is to be created are located in the only diagrammatically presented reservoirs 21 and 22. From these reservoirs, the components can be supplied, via the respective lines 23 and 24, to the spray head , with the pumps 25 and 26 being used to supply the components to the spray head under a preset pressure. Near the spray head or built into the spray head you find the pressure regulators 31 and 32, one for each component.
To accurately set the pressure under which each component is to be supplied to the spray head, the pressure gauges 29 and 30 that measure the pressure are located as closely as possible to the end of each conduit 23 and 24. The signals measured by these gauges 29 and 30 are supplied to a processor (not shown in the figure), which compares the signals with preset values representing desired pressure values, and which, if the preset values are deviated from, transmits control signals to the corresponding pressure regulators 31 and 32, respectively. Preferably, these pressure regulators are located either as closely as possible to the spray head or within the spray head, so that the influence of the remaining part of the relevant conduit 23 or 24 is minimised.

While control based on pressure only is possible, in principle, better control results will be obtained if the flow rate of the components through the conduits is also taken into account. So, it is preferable that a flow rate detector is placed either near or in the spray head, that is the detector 33 in the conduit 23, and the detector 34 in the conduit 24. The signals generated by these detectors are also supplied to the processor (not shown in the figure) for comparison with preset values. If the values are different, the processor will send control signals to the pressure-reducing valve 35 or 36, or to both valves.

If the temperature of the components plays an appreciable role, it would be preferable to mount a heating element into at least the conduits 23 and 24, and to incorporate this, along with a temperature sensor in the spray head, into a thermostat circuit, allowing the conduits 23 and 24 to be maintained at a certain temperature.

Preferably the chambers 17 and 18 are not rectangular to the shaft 14 but extend under a certain angle in relation to the shaft 14. Therefor the above used term “disk shaped space” should include also “saucer shaped”, “basin shaped “, etc. During operation, the components of the coating material will be pumped from the reservoirs 21 and 22, through the pumps 25 and 26, to the spray head. As the figure shows, the one component ends up in the chamber 17 and the other component ends up in the chamber 18.

As both chambers rotate, the components in these chambers are subjected to centrifugal forces, so that the components move from the shaft 14 to the outer sides of the chambers. As the figure clearly shows, the generally disc-shaped chambers 17 and 18 have a gap on the diametrical inner side, through which gap the relevant component can enter the chamber from the relevant conduit 23 or 24. On the diametrical outer side, too, the chambers are open. So, there, the components are radially flung out from the chambers towards the target plane 19, which is a part of the part 12 of the spray head. Because of the sloped embodiment of the chambers the component introduced in chamber 17 will move through the chamber mainly along the inner wall of form part 11, whereas the component introduced in chamber 18 will move through said chamber mainly along the inner wall of form part 12 This attributes to keeping both components separated even at the moment they the leave the respective chambers. After leaving the chambers the components may become gradually mixed depending on the speed they have obtained, their consistency, their tendency to spread out, etc.

In this respect it is remarked that the component will form a rather thin layer on the inner wall of part 11. Suppose that the motor 20 rotates with 30000 revolutions per minute and that the respective component is supplied at 6 litres per minute. Suppose further that the diameter of the chamber is 100 mm then the thickness of the film on the chamber wall at the outer edge will be in the order of 1,5 to 2 micrometers.

Whilst the radial outer sides of both chambers are close to one another, the components, having left the chambers, will yet run mainly parallel to one another until they reach the target plate 19. This target plate, which makes an angle to the axial direction set by the shaft 14, ensures that the flow direction of both components changes. Both components flow across the plate to the plate's axial outer edge, and will be thoroughly mixed thereby. Next, the thoroughly mixed components will be diametrically flung out – from the edge of the target plate in the direction of the wall to be coated.

During the transfer from the spray head there will already be some curing of the material but not yet to the extent that the material cannot spread across the wall to form a smooth coat. On the other hand, the curing must be so quick that no more movement will be possible in the smoothened coating, and that the coat cures smoothly, and without 'sags'.

As the components of the coating material do not mix until on the target plate, the risk of obstruction of, for instance, the chambers 17 and 18 or the lines 23 and 24 is

extremely small, if not nil. The only place where cured material could occur during operation is the target plate 19. To minimise the risk of adhesion of curing material to the target plate, it is preferable either to provide the target plate with a layer of smooth material with poor adhesive characteristics or to make the whole part 12 of such material. Suitable materials are nylon, polyurea, teflon, and PEEK. Polyurea, in particular, that is maintained at an increased temperature for some time after the curing, appears to form a suitable hard smooth layer that is difficult for other materials to adhere to. If this additional processing step is not made, teflon or PEEK is preferred.

If yet, despite all precautions, adhesions of cured coating material should occur on the target plate, the part 12 is easy to detach from the spray head for cleaning or for replacement with a clean part 12.

A preferred construction material is carbon reinforced PEEK.

Figure 2 again presents diagrammatically the already designated parts which, together with the processors not yet shown, make up the control circuit. The processor 37 controls the first material component, receives input signals from the pressure gauge 29 and from the flow meter 33, and sends control signals to the pressure regulator 31 and the flow regulator 35. The pressure gauges 29's signal, which is representative for the input pressure Pi, is compared by the processor with the set value Ps. The flow meter 33's signal, which is representative for the input flow Fi, is compared by the processor with the set value Fs. If the set values are deviated from, control signals will be calculated using an appropriate algorithm, and sent to the regulators 31 and 35. The algorithm should take into account that the two regulators have an influence on each other.

The processor 38 controls the second material component, receives input signals from the pressure gauge 30 and from the flow meter 34, and sends control signals to the pressure regulator 32 and the flow regulator 36. The pressure gauge 30's signal, which is representative for the input pressure Pi, is compared by the processor with the set value Ps. The flow meter 34's signal, which is representative for the input flow Fi, is compared by the processor with the set value Fs. If the set values are deviated from, control signals will be calculated using an appropriate algorithm, and sent to the regulators 32 and 36. Here, too, the algorithm should take into account that the two regulators have an influence on each other.

Not only pressure and flow need to be controlled but also the ratio between the

two components must meet certain requirements. So, some adjustment of the flow of the one material component will affect the flow of the other component. This is represented in the figure by the bi-directional interface 39 through which the two processors communicate with each other. It is obvious that the function of the two processors may also be performed by one single processor.

Not only signals relating to pressure and flow of the components need be supplied to the processor but also information on the temperature of the components, the forward speed of the spray head in axial direction, and the rotational speed of the spray head may constitute important input signals for the processor(s).

Based on all these input signals, the pressure and flow of the components are to be controlled, it being assumed that the axial forward speed and the rotational speed of the spray head are set as fixed values, and that the component temperatures may also be considered fixed. When this information is available, an expert will have no trouble defining the required control algorithms and writing the corresponding software, so this need no further elaboration.

As flow and pressure are controlled in the immediate vicinity of or even within the spray head, the pumps 25 and 26 only have to meet requirements as to minimum pressure needed to pump the relevant material component through the lines and deliver it to the spray head at pressure Pi, which allows the control process to function properly.

Figure 3 illustrates a somewhat modified embodiment of a spray head according to the invention. Those details, which are not altered in comparison with figure 1, are indicated with the same reference numbers.

A first difference between figures 1 and 3 is found in the shape of the target plate. This plate carries in figure 3 the reference 19' and extends at a different angle to the shaft 14. Furthermore the length thereof is shorter so that both components will reside shorter on the target plate. For some components this might be preferable.

A second difference resides in the embodiment of the tubular section of form part 13. The inner wall of said tubular section, which surrounds the shaft 14 is not smooth as in figure 1, but carries a spirally shaped ridge, indicated by reference number 13'. In the operating situation wherein this spirally shaped ridge rotates said ridge will have a pushing effect on the component transported through conduit 23. Said component is transported by said ridge from the end of conduit 23 to the entrance of chamber 17. The

centrifugal forces in chamber 17 are effecting the further transport. It will be clear that a similar ridge can be installed on the inner wall of the tubular section of form part 12 for transporting the component pumped out at the end of conduit 24.

A third difference resides in the position of the parts 29, 31, 33 and 35 respectively 30,32,34 and 36. The order is changed into 33, 35, 29, 31 respectively 34, 36, 30, 32. In many cases the flow is the more significant value to be controlled and therefore a flowmeter at the end of the conduit is preferable.

A fourth difference resides in the presence of two pressure reservoirs 41 and 42. From these reservoirs pressurised air or other suitable gas can be supplied to the spraying head in a similar manner as the material components are supplied. The gas flow is controlled by control circuits 43 and 44 in the respective conduits 45 and 46. Just introducing air (or another gas) will enhance the movement of the components through the various sections of the spraying head. Furthermore the gasflow can be used to introduce particles such as grains of sand, fibre particles etc. into the head to become mixed with the respective component. It will be clear that these particles will have influence on the characteristics of the coating sprayed by the gun on the wall of the tunnel, etc. On the other hand adding particles to the component stream will decrease an eventual tendency of the respective component to adhere to parts of the spray head. Especially the eventual tendency of the mixed and already curing components to adhere to the target plate is reduced. The specific means necessary to bring particles into the gas stream are not shown separately in the figure.

Without detailed illustration it will be clear that the places where the various conduits 23, 24, 45 and 46 enter the spraying head preferable are sealed in a suitable manner e.g. by means of a sliding coupling to prevent any particles entering the spray head from that side.

It will be further clear that it is possible to supply a flow of materials to multiple spray heads at the same time, if necessary. One may think of a situation where two spray heads are mounted onto the same shaft at some distance from each other, and are moved together through a tunnel to be coated. The front spray head applies a first layer of coating material. This layer may have cured sufficiently after, for instance, 10 seconds to then serve as a substrate for a second coat sprayed by the second spray head. Each spray head has its own control system, with both heads being fed through the same conduits. In this way, it is possible to apply coatings of large thickness. Benefits

of this process are that the vehicle onto which the spray heads are mounted can be moved through the tunnel in a uniform motion, and that no further moving parts are needed.

It is obvious that multiple coats can also be applied using one single spray head that is connected to the vehicle through a reciprocating mechanism. The vehicle is moved through the tunnel at a preset speed while, at the same time, the spray head is axially moved in a reciprocating motion across a preset length. If the reciprocating mechanism moves the head in both directions at the same speed, the relative speed of the head in relation to the tunnel wall will strongly differ as for the reciprocating motion, which would lead to the thickness of the applied coating also varying strongly. This will be undesirable in most cases. It is therefore preferred to control the reciprocating mechanism, at a preset axial forward speed of the vehicle, in such a way that the spray head will have a relatively low speed when moving in the same direction as the vehicle, and a relatively high speed when moving in opposite direction, such that in either direction the speed will be equal in relation to the wall. This ensures that, irrespective of the direction of movement in relation to the wall, the sprayed-on coat will always be of equal thickness. Furthermore it will compensate any irregularity in the wall coating by a spraying a higher or lower material flow through the spray head in different directions.

As a refinement it is preferred that the spray head makes an oscillatory movement with small deflection in the direction of movement and reverse. The result thereof is that the coating layer will be smoother and can be applied thicker.

The number of layers that can thus be sprayed on top of each other depends on the actual speeds. If two layers suffice, the speeds should be selected such that, at the end of its route, the spray head, when moving in opposite direction to that of the vehicle, always reaches the point halfway the preceding route. Similar considerations apply for multiple layers on top of each other. The control system can be programmed by software in such a manner that the spray head automatically applies a predefined coating thickness based on the pipe diameter as input parameter. The correct settings are deemed to be within the competence of an expert, so they need no further explanation here.

In general, it will not be necessary for the coating to adhere to the wall very strongly. If the coat is of sufficient thickness, thus having sufficient capacity of its own

to retain its form, it will not be a problem if the coat comes off the wall at some places, for instance, due to temperature influences. Thus, a coat of sufficient thickness will also be able to span, for instance, cracks or other small irregularities or openings in the wall. To form such a coating, it will however be necessary in most situations to create a substrate that receives the coating and allows it to cure in the correct form. In other words, holes, cracks and other openings to be spanned by the coating are preferably sealed with a material that has to perform a supporting function only for a short period of time. One may think of spraying concrete mortar or any other gap-filling material, but this will not always produce the desired result with larger and/or deeper openings. It has turned out that textile material does produce satisfactory results, though. To fix textile material temporarily, use may be made of adhesives or glues that are either sprayed on separately or integrated into the textile material. Apart from the fact that textile material is easy to apply in all kinds of forms, thus being able to follow all kinds of contours, it is also essential that textile material is air-permeable. When coating material is sprayed on a layer of textile, the coating will be able to penetrate into the textile material's pores easily and without resistance, so that the textile will not only support but also strengthen the coating. In stead of textile other materials such as woven metal can be considered.

Claims

1. Spray head for spraying a coating onto the inner wall of a tunnel, pipe, tube or other elongated space of relatively limited diameter, which spray head has a central shaft that runs in longitudinal direction during operation and can be rotated by a driving motor with or without gear box, characterised in that, for each component, the spray head has a mainly diametrically extending disc-shaped acceleration room, whose diametrically smallest shaft-oriented inner side is connected, through a known coupling, to a component supply channel, and whose diametrically largest outer side is open, at least partially, forming a discharge gap through which the relevant component is flung out in approximate diametric direction during operation.

2. Spray head according to claim 1, characterised in that at least one wall of each disk shaped acceleration room extends not perpendicular to the central shaft but with an angle somewhat smaller then 90 degrees thereto.

3. Spray head according to claim 2, characterised in that the design of the shaft orientated inner side of each room is such that the component entering the room will be guided mainly to said non-perpendicular wall.

4. Spray head according to one of the preceding claims, characterised in that the spray head has a flat, plate-ring-shaped target plate, which is located on the fling-out route of each of the components, and whose inner side makes an angle to the axial direction such that the components end up on this target plate, and are moved to the edge of the target plate by the centrifugal force, whereby the components are mixed and flung out over the edge.

5. Spray head according to any of the preceding claims, characterised in that at least the inner side of the target plate is made of or lined with a material that has poor adhesive characteristics.

6. Spray head according to claim 5, characterised in that at least the inner side of

the target plate is made of or lined with any of the following materials:-

polyethylene
polyurea
quartz oxide
aluminium oxide
teflon
nylon
PEEK
PEEK with carbon reinforced

7. Spray head according to any of the preceding claims, characterised in that the component with the highest liquidity is guided through the spray head such that it will move across the target plate longer, and that the component with the lowest liquidity is guided through the spray head such that it will move across the target plate shorter.

8. Apparatus for spraying a coating onto the inner wall of a tunnel, pipe, tube or other elongated space of relatively limited diameter characterised in that the apparatus comprises two or more spray heads of the type described in one of the preceding claims.

9. Control system for the control of the spray head as described in any of the preceding claims, characterised in that, for each supply channel, the spray head is equipped with a flow meter and a control valve, with each flow meter transmitting a signal to a processor that compares the signal with a set value, which comparison produces a control signal for the control of the relevant flow control valve.

10. Control system according to claim 9 characterised in that, for each component, a temperature meter is coupled to the relevant supply channel, and that all temperature meters transmit signals to the processor which, based on those signals, corrects the control signals to the control valves.

11. Control system according to claim 9 or 10, characterised in that there are heating means that ensure that each of the components in the supply lines has a preset tem-

perature on entering the relevant spraying room.

12. Control system according to claims 9 or 10, characterised in that the heating means can be controlled by the processor based on the temperature signals received.

13. Control system according to any of the preceding claims 9 to 12, characterised in that there is a pressure control valve for each component; that, for each component, there is a pressure gauge that transmits pressure signals to the processor; and that the processor controls the pressure control valves based on the pressure signals received.

14. Control system according to any of the claims 9-13, operating under control of software which determines the thickness and the number of layers of the coating based on the diameter of the tunnel, pipe, tube or other elongated element as input parameter.

15. System for the treatment of walls of tunnels, pipes, tubes or other elongated, mainly horizontal spaces of limited diameter, which system includes:-

- reservoirs for storing the coating components;
- a spray head for applying the coating onto the tunnel wall;
- conduits between the reservoirs and the spray head for supplying the coating from the reservoirs to the spray head;
- means for moving the spray head through the tunnel,

characterised in that the spray head is embodied as described in any of the claims 1 to 7.

16. System for the treatment of walls of tunnels, pipes, tubes or other elongated, mainly horizontal spaces of limited diameter, which system includes:-

- reservoirs for storing the coating components;
- a spray head for applying the coating onto the tunnel wall;
- conduits between the reservoirs and the spray head for supplying the coating from the reservoirs to the spray head;
- means for moving the spray head through the tunnel,

characterised is that the spray head is controlled by a control system as described in any of the claims 9 to 13.

17. System for the application of coatings consisting of at least two components onto walls of tunnels, pipes, tubes or other elongated, mainly horizontal spaces of limited diameter, which system includes:-

- means for pre-treating tunnel walls by applying a layer of textile or flexible metal onto spots where the wall is damaged;
- a spray head as described in any of the claims 1 to 7;
- means for moving the spray head through the tunnel;
- a reservoir of the two components outside the tunnel;
- conduits for feeding the two components from the reservoir to the spray head;
- a control system for the control of the supply of each of the components, as described in any of the claims 9-13.

18. System according to one of the claims 15-17, characterised in that the means for moving the spray head comprise a frame which is able to move through said tunnel, etc., a spray head carrier carrying the one or more spray heads, whereby means are present to bring the carrier in a zigzag movement in relation to said frame.

19. System according to claim 18, characterised in that said means are further able to interpolate a small oscillatory movement on top of said zigzag movement.

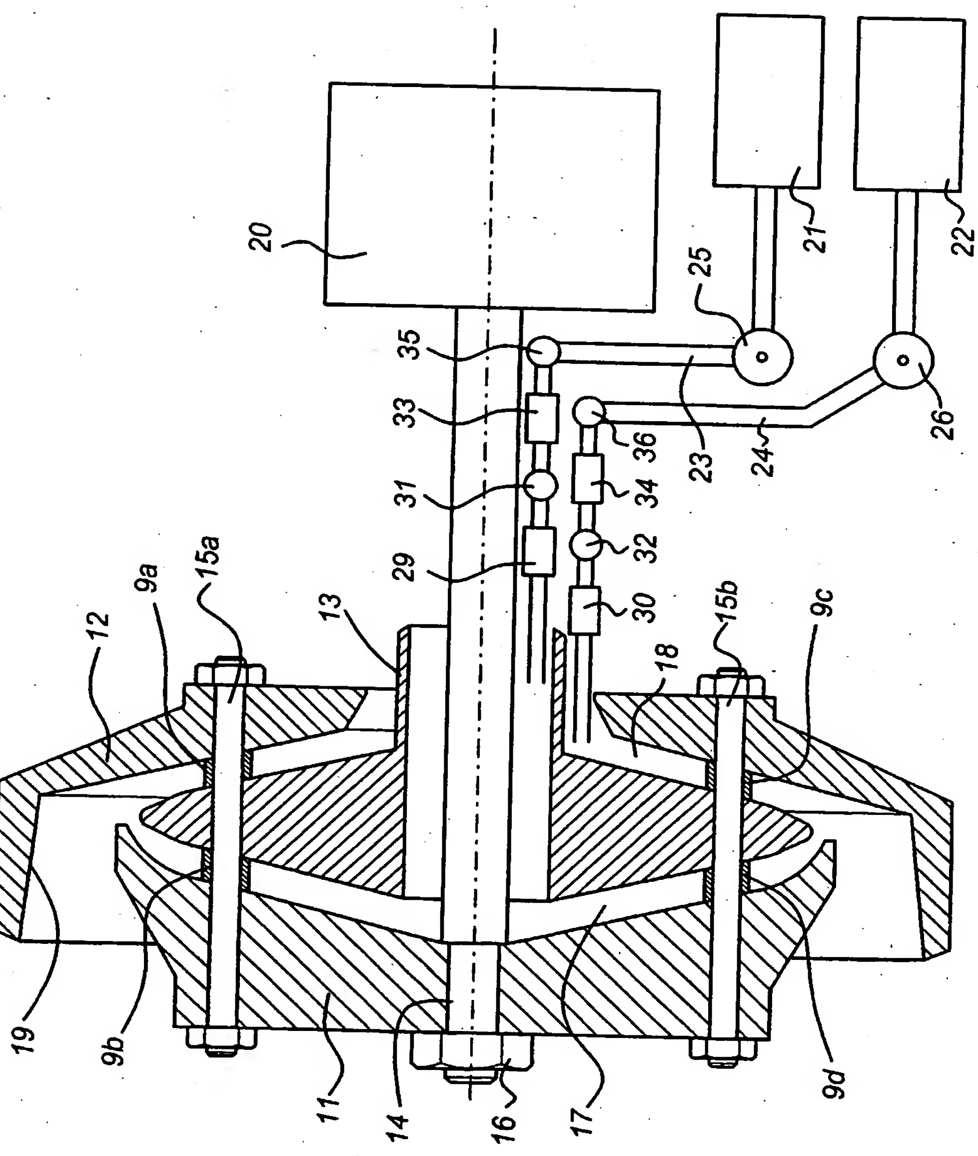
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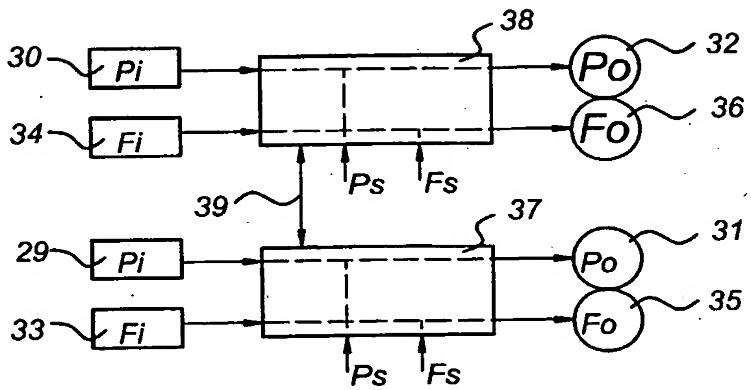
Fig 1

Fig 2



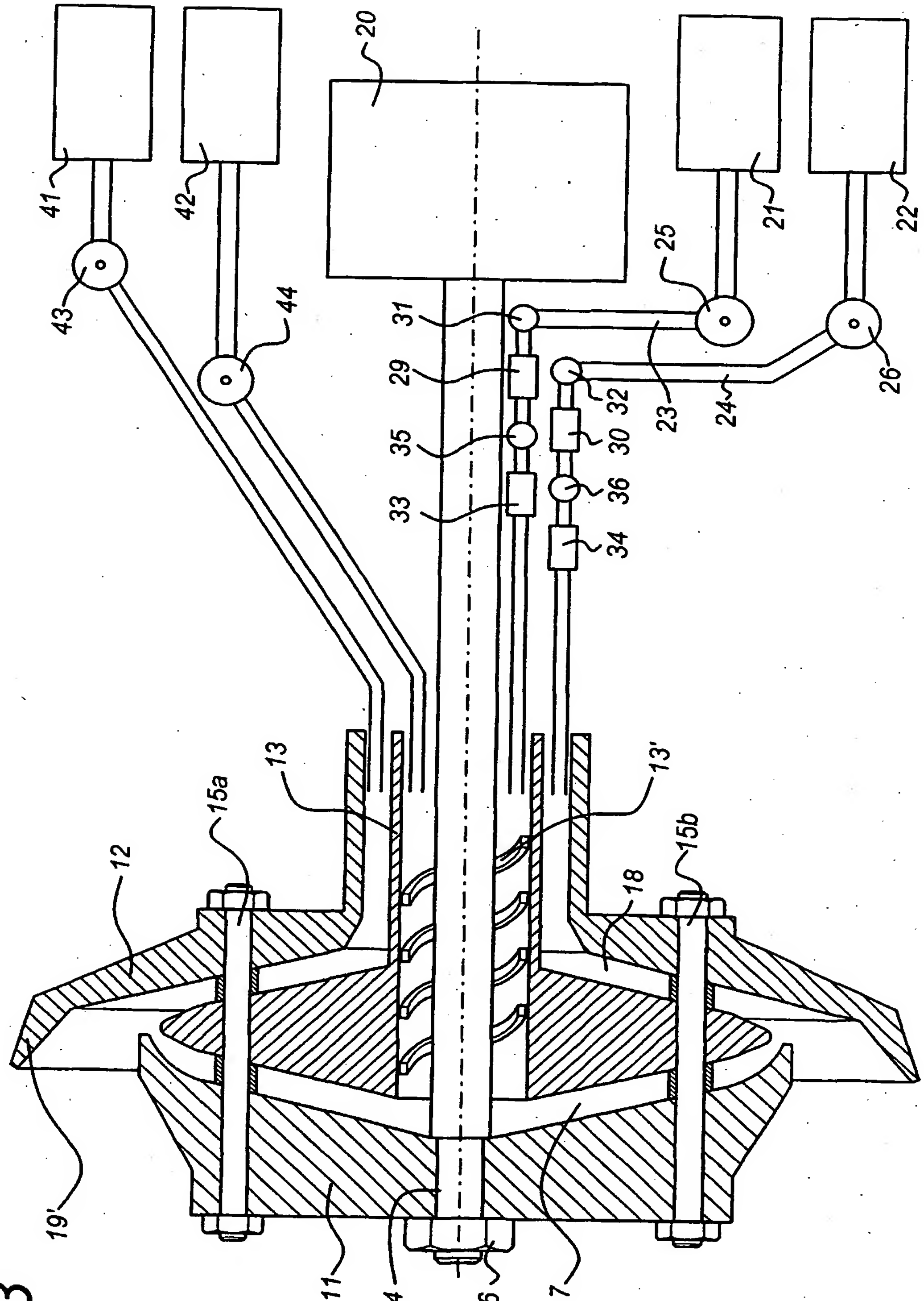

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Fig 3

INTERNATIONAL SEARCH REPORT

Inte ial Application No
PCT/NL 02/00674

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B05B3/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

PAJ, EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 January 2003	29/01/2003
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Brévier, F

INTERNATIONAL SEARCH REPORT

Int· al Application No
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